Akira Uedono

Division of Applied Physics, Faculty of Pure and Applied Science,
University of Tsukuba, Tsukuba, Ibaraki 305-8573, Japan

Contents

- Introduction of Tsukuba
- Partnership program between University of Tsukuba and DAAD (Deutscher Akademischer Austausch Dienst)
- Basics of positron annihilation
- Study of vacancy-type defects in $Cu(In,Ga)Se_2$

つくば市 わたしのつくばをみつけよう。 TSUKUBA CITY

Facilities

- National research facilities: 32 (1/3 in Japan)
- Private research facilities: 120
- National University: 1 (University of Tsukuba)

Researchers

- 2,000 researchers (10% of city population)
- 8,000 doctoral researchers
- 5,000 oversea researchers

University of Tsukuba

Regular staff members	
President	1
Trustee	6
Organizer	2
Professor	606
Assoc. Prof.	520
Lecturer	403
Asst. Prof.	128
Others	606
Admin. staff	1900
Total	4182

Undergraduate:	10,190
Graduate:	6,556
Total:	16,746

International Students	
From China:	656
From Asia:	1,235
Total:	1,527

Schools and Colleges (Undergraduate Courses)

School of Humanities and Culture
- College of Humanities
- College of Comparative Culture
- College of Japanese Language and Culture

School of Social and International Studies
- College of Social Sciences
- College of International Studies

School of Human Sciences
- College of Education
- College of Psychology
- College of Disability Sciences

School of Life and Environmental Sciences
- College of Biological Sciences
- College of Agro-Biological Resource Sciences
- College of Geoscience

School of Science and Engineering
- College of Mathematics
- College of Physics
- College of Chemistry
- College of Engineering Sciences
- College of Engineering Systems
- College of Policy and Planning Sciences

School of Informatics
- College of Information Science
- College of Media Arts, Science and Technology
- College of Knowledge and Library Sciences

School of Medicine and Medical Sciences
- School of Medicine
- School of Nursing
- School of Medical Sciences

School of Health and Physical Education

School of Art and Design

University Exchange Agreements

About the University Exchange Agreements and Current Achievements of the International Exchange Program with Germany

The University of Tsukuba cooperates with 11 German universities under the framework of student exchange programs. Joint research and academic exchange is available in numerous research fields.

List of Participating Schools

- University of Bonn University-level Agreement
- University of Bayreuth University-level Agreement
- Free University of Berlin University-level Agreement
- University of Stuttgart University-level Agreement
- University of Leipzig Department-level Agreement
- Ruhr-University Bochum Department-level Agreement
- Martin Luther University Halle-Wittenberg Department-level Agreement
- Brandenburg University of Technology, Cottbus Department-level Agreement
- Ludwig Maximilian University Munich Department-level Agreement
- Bielefeld University Department-level Agreement
- Augsbur University of Applied Sciences Department-level Agreement

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MOU between University of Tsukuba and DAAD (15th Feb. 2012)

10.02.2012

Besuch der DAAD-Generalsekretärin in Tokyo

Die Generalsekretärin des DAAD, Dr. Dorothea Rüland, besucht vom 12. bis 20. Februar auf Einladung des japanischen Außenministeriums Japan. Ihr Besuch soll gerade jetzt, beinahe ein Jahr nach der Erdbeben- und Nuklearkatastrophe vom März 2011, die Bedeutung der wissenschaftlichen Kooperation zwischen Deutschland und Japan unterstreichen. Angelehnt an das Jahresthema des DAAD „Gesellschaft im Wandel – Wandel durch Austausch" liegt dabei ein besonderes Augenmerk auf der Rolle des wissenschaftlichen Austauschs für die Erarbeitung von Lösungsstrategien für Probleme, die beide Länder gleichermaßen beschäftigen. Während ihres Aufenthalts wird Dr. Rüland neben dem japanischen Außenministerium auch mit zahlreichen Partnerorganisationen und Hochschulen, wie der Japan Society for the Promotion of Science (JSPS), der Universität Tokyo, dem Tokyo Institute of Technology und weiteren Einrichtungen über die weitere Zusammenarbeit und neue Chancen des bilateralen akademischen Austauschs sprechen.

日独交流150周年
Jahre Freundschaft
Deutschland – Japan

Partnership program between University of Tsukuba and DAAD

Deutscher Akademischer Austausch Dienst

http://www.tsukuba.ac.jp/topics/20120220142130.html

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Pre-strategic project for UTAC

University of Tsukuba supports UTAC for i) establishing active research communities in Tsukuba area and ii) scientific relationships between UT and foreign research groups.

12MV Pelletron tandem accelerator

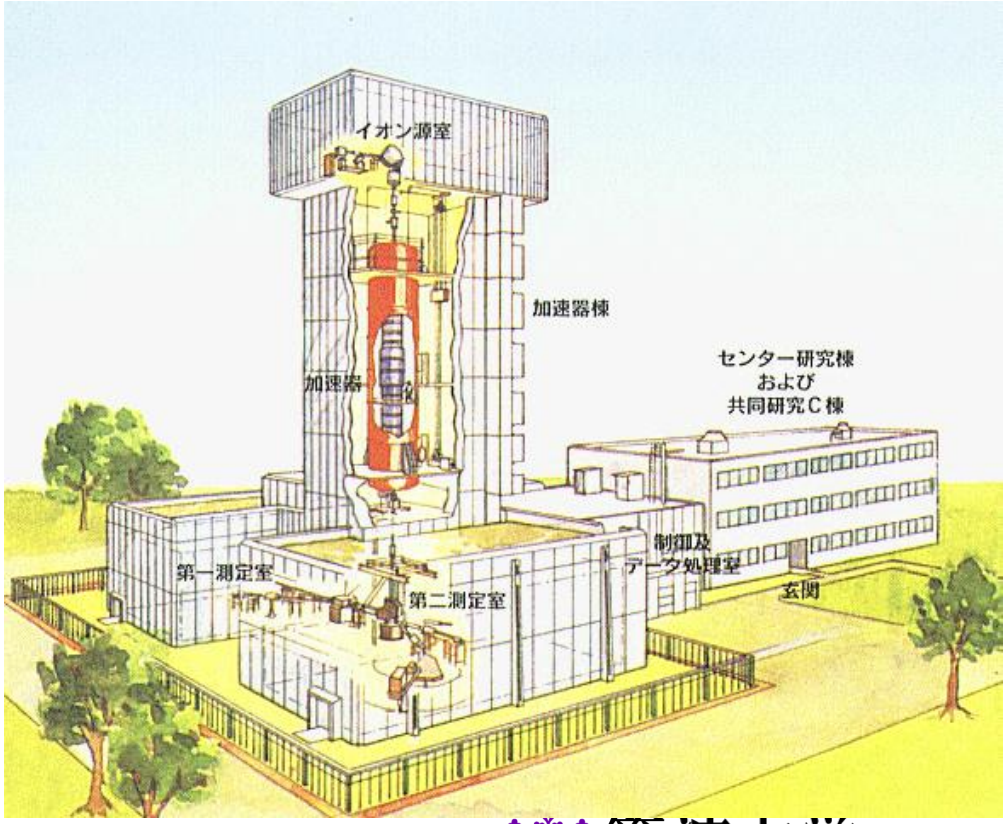
- Ion implantation
- Nano scale Material design
- Ion scattering (RBS)
- AMS (Cl-36)
- Isotope analysis
- ERCS

1 MV tandetron accelerator

- RBS/ERDA
- PIXE

Facilities using RI

- Positron annihilation
- Mössbauer spectroscopy



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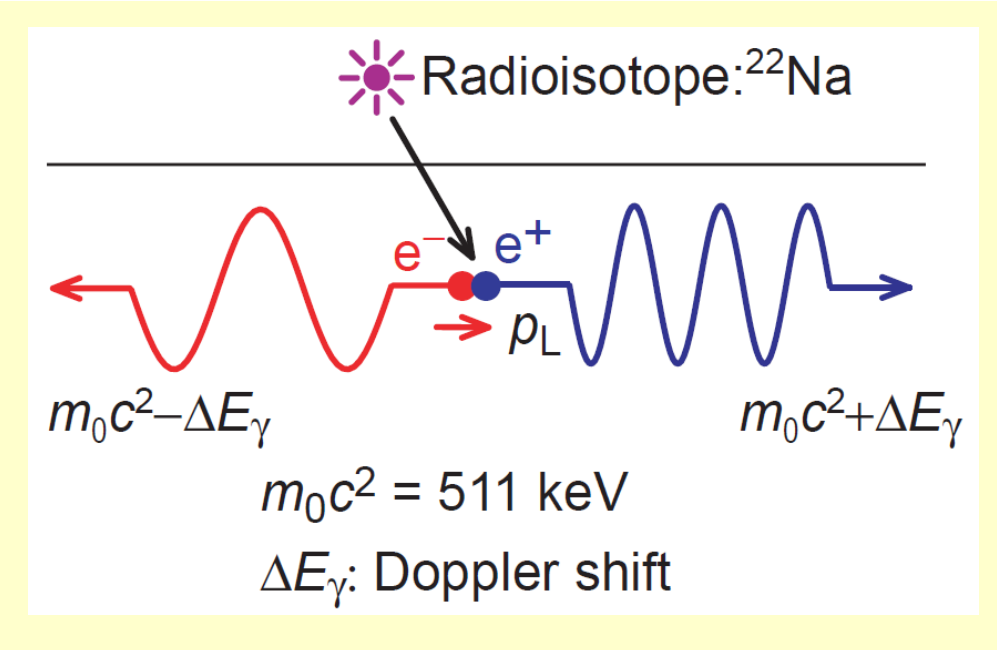
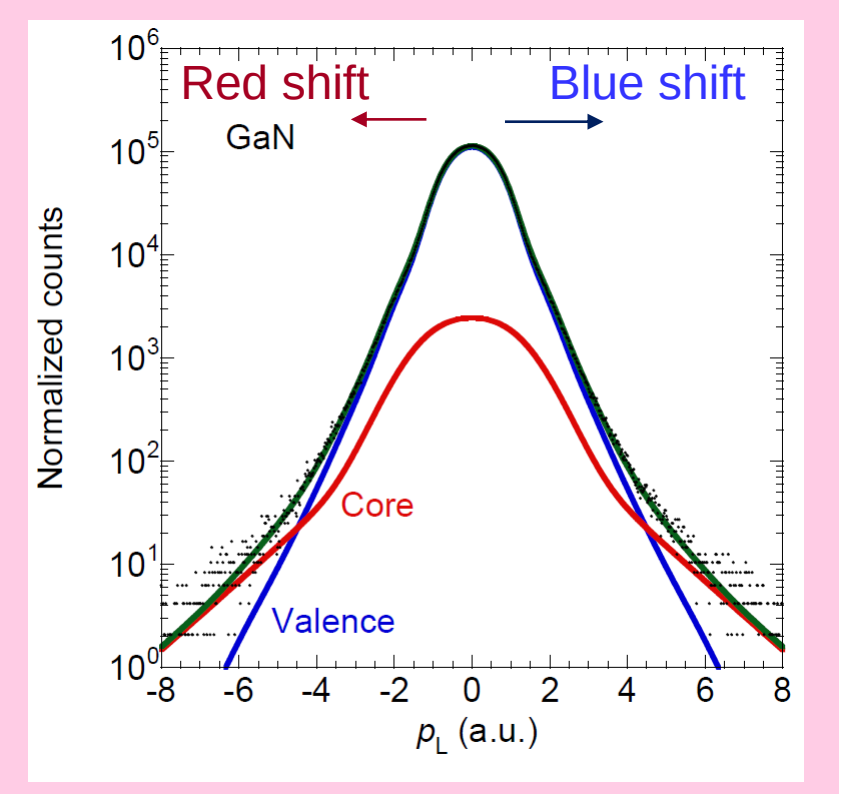
Doppler broadening of the annihilation γ-rays





Because of the energy and momentum conservations, the energy of γ rays is broadened due to the electron momentum, p_L (parallel to the direction of the γ rays).

$$E_\gamma = m_0c^2 \pm \Delta E_\gamma = m_0c^2 \pm cp_L/2$$

Doppler shift

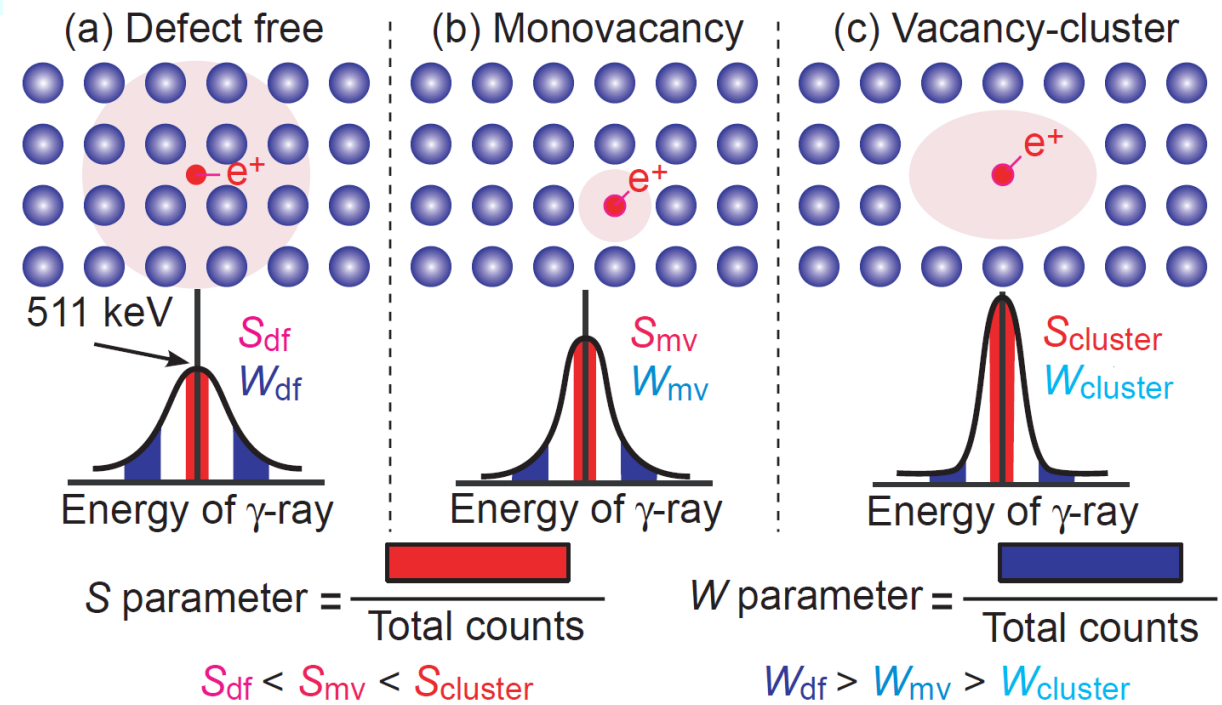
Electron momentum

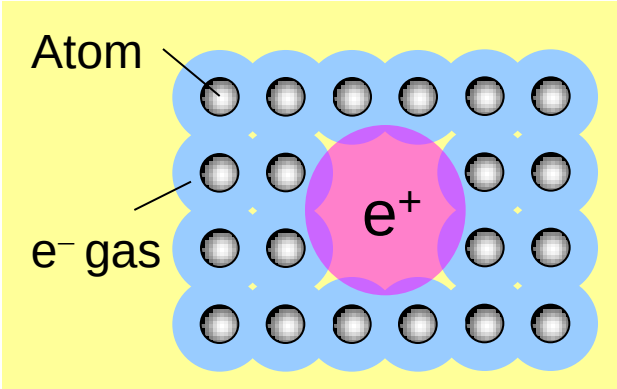
Energy of γ−rays

(1 a.u.=7.297 mrad = 1.86 keV)

Trapping of positrons by vacancy-type defects

A freely diffusing e^+ may be localized in an open space because of the Coulomb repulsion from ion cores.





Electron density in vacancies is lower than that in interstitial site.

⇩

Increase in the positron lifetime

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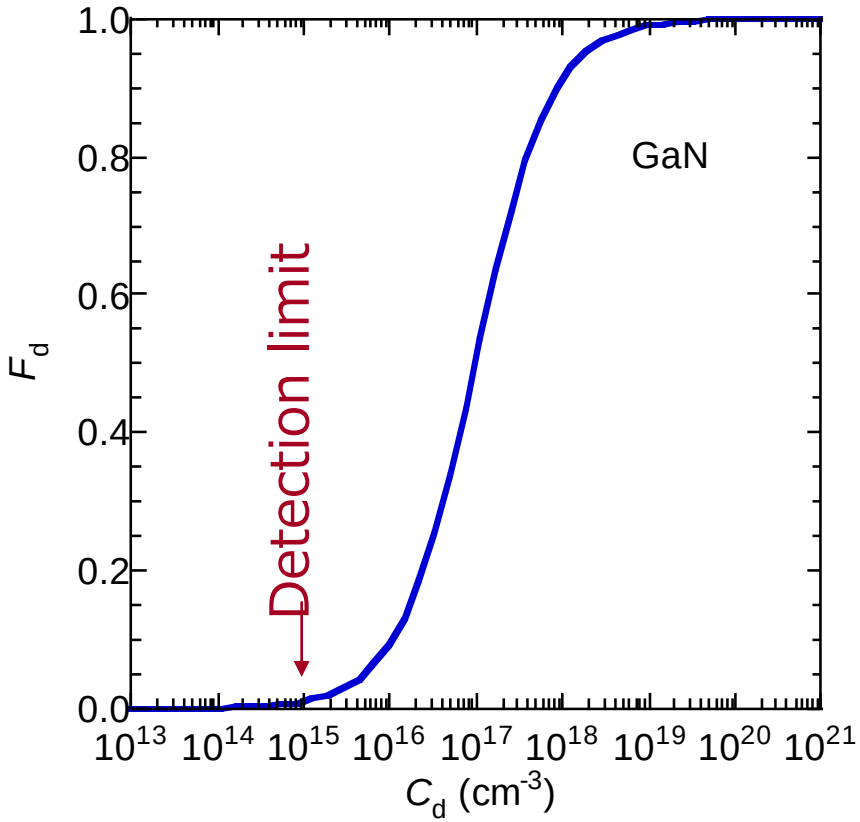
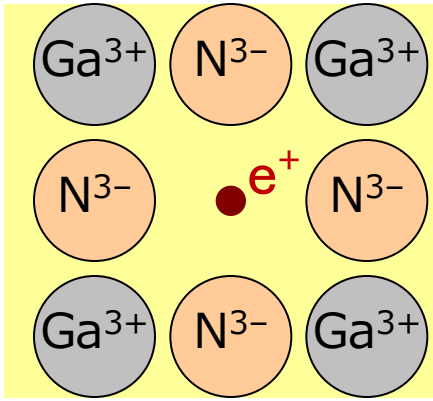
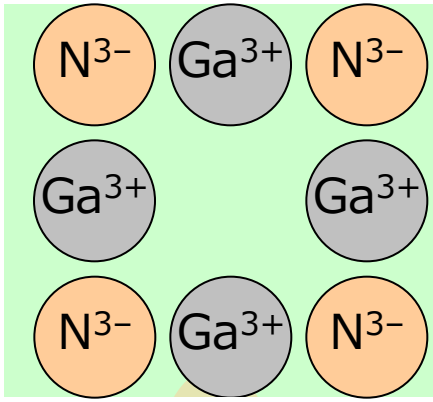
Detection of vacancy-type defects using PAS



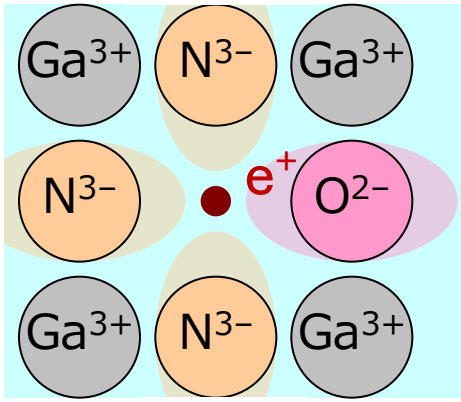
Positron trapping fraction of defects, F_d , for V_{Ga} in GaN.



Coulomb attraction from negatively charged *V*.

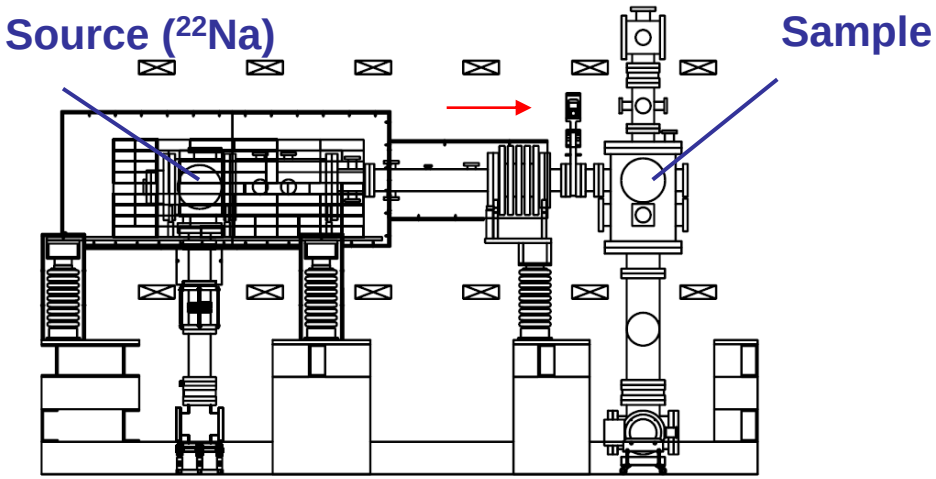


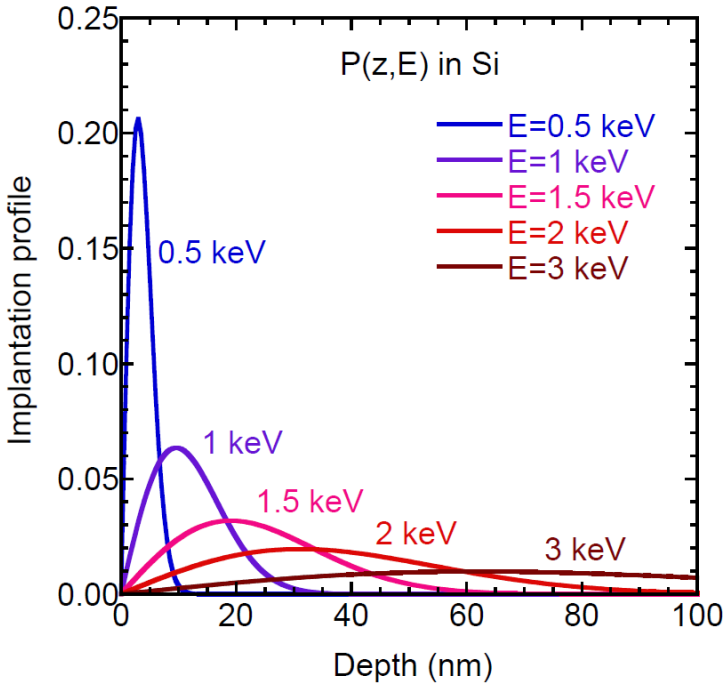
Coulomb repulsion from positively charged *V*.

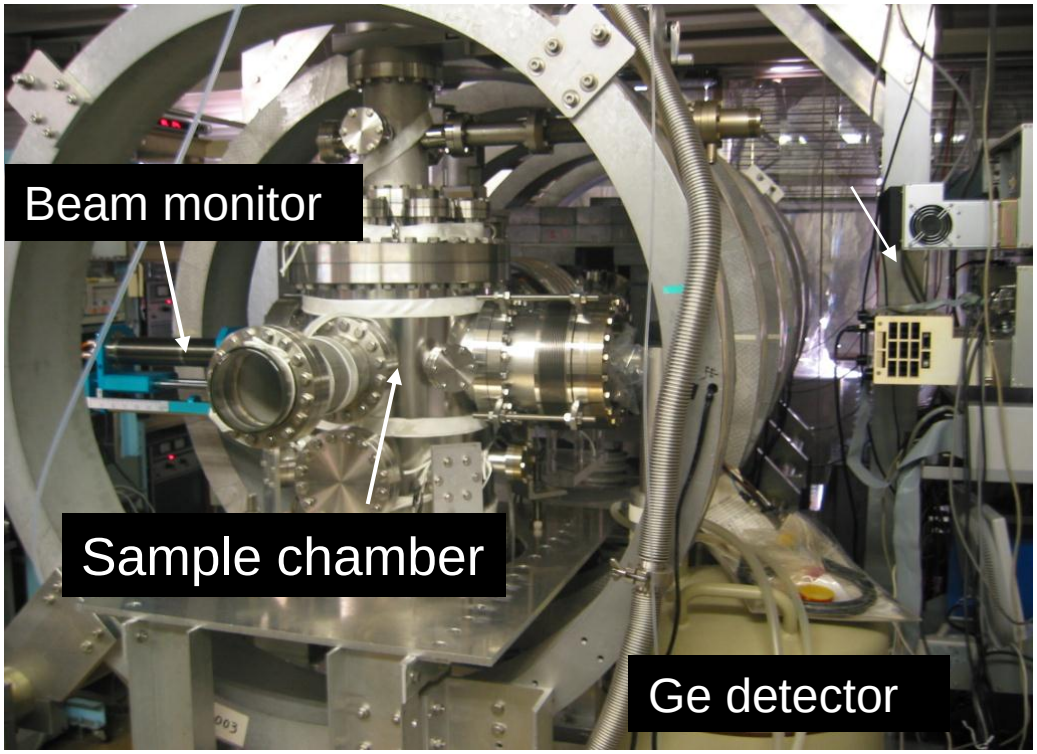


Change in electron momentum due to coupling with impurities.

Monoenergetic positron beam in University of Tsukuba







Positron beam (ϕ3-10 mm)

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Vacancy-type defects in $Cu(In,Ga)Se_2$ probed by positron annihilation

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T. Sakurai, and K. Akimoto
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A. Yamada, S. Ishizuka, K. Matsubara, and S. Niki
Research Center for Photovoltaics, National Institute of Advanced Industrial Science and Technology,
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S. Ishibashi
Nanosystem Research Institute (NRI) "RICS", National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki 305-8568, Japan

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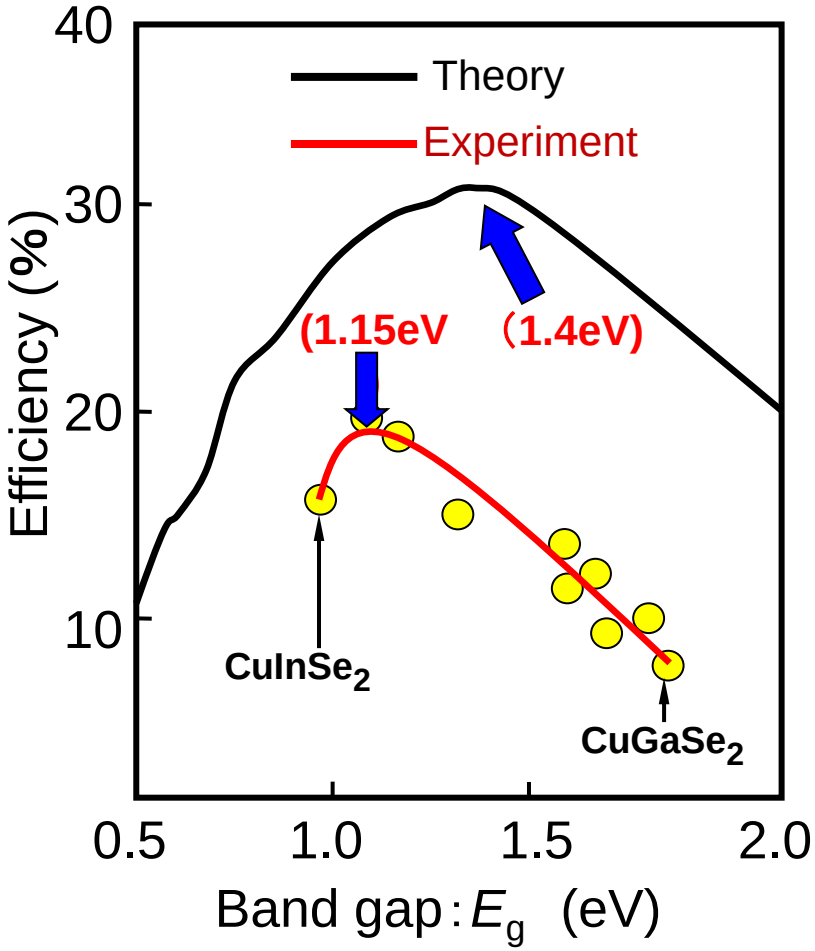
Background of $Cu(In,Ga)Se_2$

$Cu(In,Ga)Se_2$ (CIGS) is the most promising materials to realize high-efficiency, low cost thin film solar cell, due to its high optical absorption as direct gap material and cost effective growth procedure.

- Complex solar cell structures
- Quaternary material
- Difficulty in the growth control (presence of multi-phase)

The efficiency is behind the theoretical prediction of 31% expecting for CIGS with E_g=1.4 eV.



S. Niki *et al.*, SEE 2006 A041.

Knowledge about defects and their correlation to the material properties is important to achieve conversion efficiency beyond the current limit

Sample preparation

AIST (Niki group) & University of Tsukuba (Akimoto lab.)

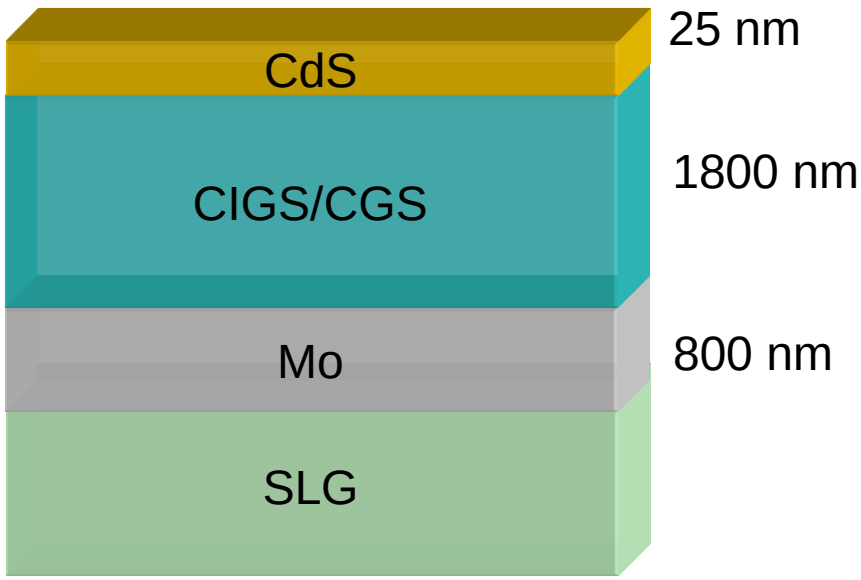
Mo deposition on soda lime glass substrate

↓

Three-stage evaporation process using MBE (see next figure)

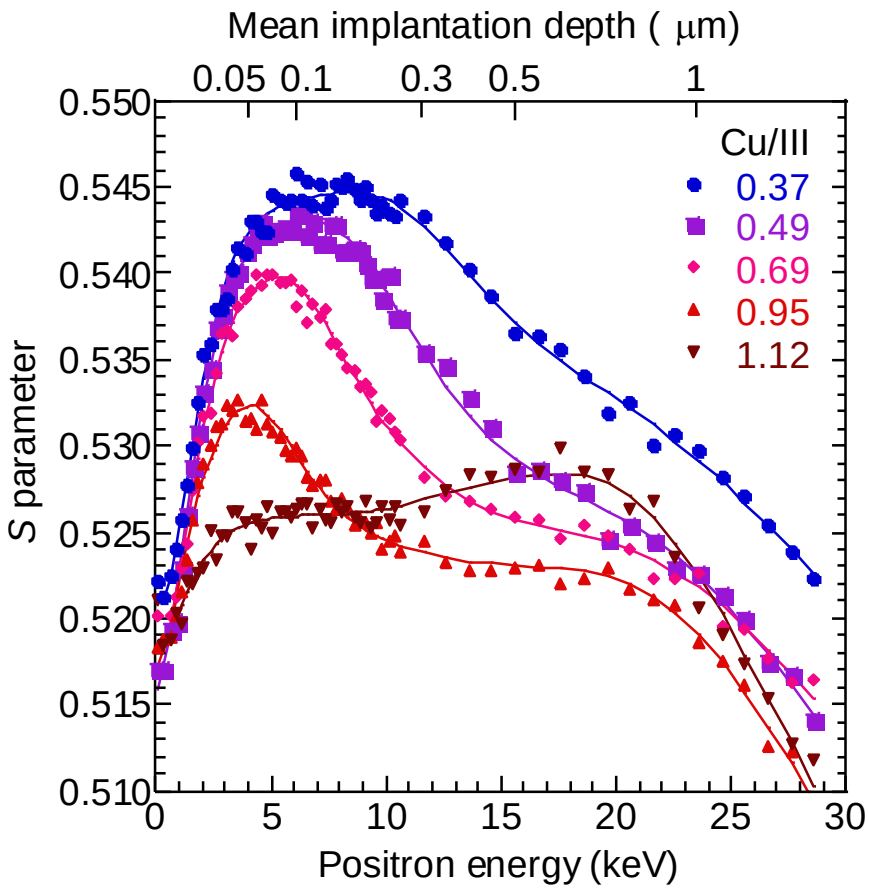
↓

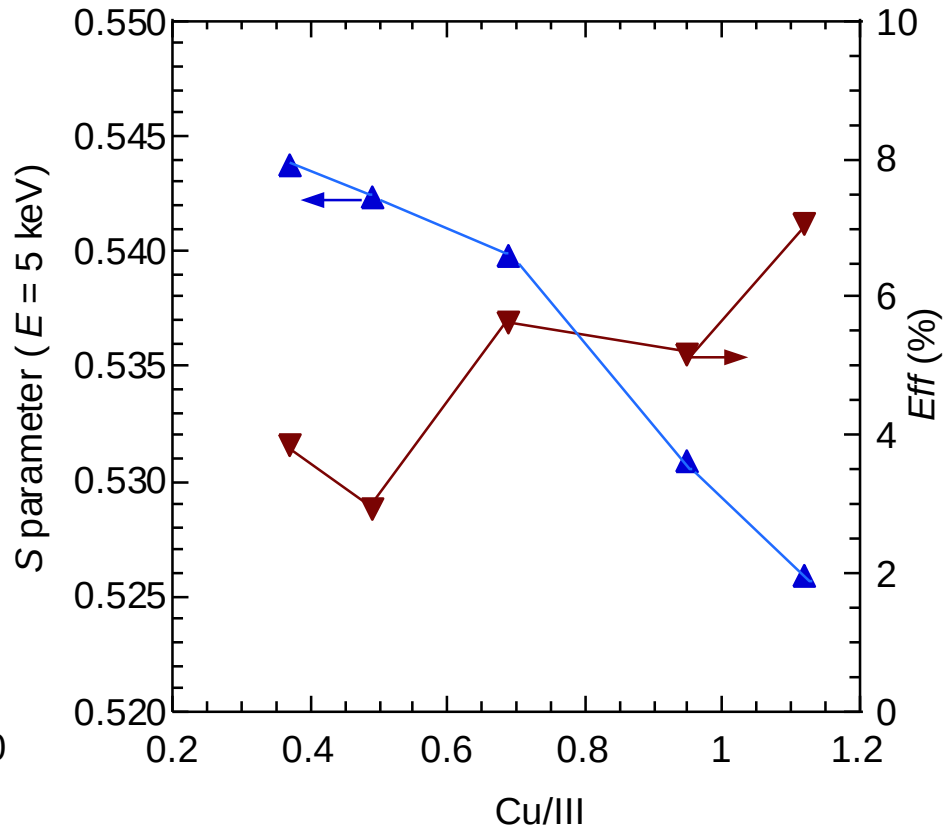
CdS layer deposition (to avoid oxidation)



Electron probe micro analyzer (EPMA) was performed to determine the material composition of the films in relation to the interpretation of results obtained through PAS technique.

Impact of Cu/III(=In+Ga) ratio on S for CGS (Se=5.8×10^{-3} Pa)





- Introduction of vacancy-type defects is suppressed with increasing Cu/III ratio.
- Conversion efficiency increased with increasing Cu/III ratio.

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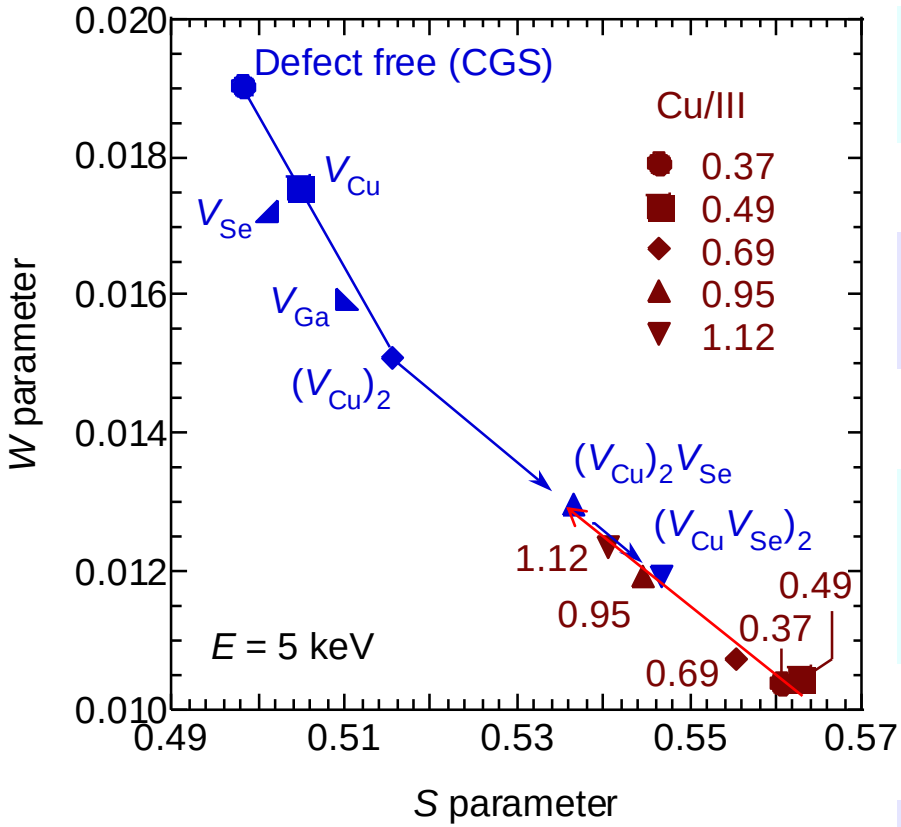
Cu/III(=In+Ga) ratio dependence during CGS



The (S,W) values observed for CGS are far from those for monovacancies.

The defects species detected by positron annihilation is vacancy clusters

The (S,W) value approaches the defect free (S,W) value along the line connects complexes between V_{Cu} and V_{Se}.

The major defects controlled by changing Cu/III ratio is the complexes between V_{Cu} and V_{Se}.

τ_1=300-330 ps (~95%)

(S/N was not good, should be confirmed)

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I am not so happy

Lot of problems we should solve.

Too many defects ?

Inhomogeneity?

Single crystal?

Grain effect?

Those open questions would be good, because if I could solve everything by myself, I do not need collaboration.